SECTION 16121
MEDIUM-VOLTAGE CABLE - 5-kV INSULATED AND 15-kV INSULATED

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawing and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.

1.2 SUMMARY

A. This Section includes the following:
   1. Medium-voltage cable, 5-kV insulated and 15-kv insulated.

B. Related Sections: The following Sections contain requirements for this Section:
   1. Section 02222, Excavation for Utilities: Trenching, excavation, and backfill.
   2. Section 16111, Conduit and Fittings.
   3. Section 16118, Underground Conduct Duct Bank.
   4. Section 16124, Splices and Terminations – Medium Voltage Cable.
   5. Section 16960, Electrical Testing.

1.3 REFERENCES

A. American Electric Insulated Cable (AEIC)
   1. AEIC CS6, Specifications for Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 kV.

B. American National Standards Institute (ANSI)
   1. ANSI/IEEE C2-97, National Electric Safety Code.

C. Institute of Electrical and Electric Engineers (IEEE)
   1. IEEE 400-91, Making High-Direct-Voltage Tests on Power Cable Systems in the Field, Guide, 14 pages.

D. National Electrical Manufacturers Association (NEMA)
   1. NEMA WC 8-88, Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

E. National Fire Protection Association (NFPA)
   1. NFPA 70, 1999, national Electrical Code (NEC)

F. Insulated Cable Engineers Association (ICEA)
   1. ICEA-S-68-516 Ethylene-Propylene-Rubber Insulated Wire and Cable

G. Underwriters Laboratories, Inc. (UL)
   1. UL-1072-1995 Medium-Voltage Cable

1.4 SUBMITTALS

A. Submit product data for approval

B. Submit test reports for approval.

1.5 QUALITY ASSURANCE

A. UL and NEMA Compliance: Provide cables that are listed and labeled by UL and comply with applicable NEMA standards.

B. Comply with NFPA 70 for electrical components devices and accessories installation.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver cable and accessories on-site in manufacturer's reels and packages and inspect for damage.

B. Protect cable and accessories from weather by covering with opaque plastic or canvas; provide ventilation to prevent condensation. Seal both ends of all cables to protect the cables against dirt and moisture during storage.

C. Leave protective cribbing on cable reels until construction is ready to receive cable.

1.7 SEQUENCING AND SCHEDULING

A. Coordinate manhole construction with pulling eye locations, duct entrances and other appurtenances to provide for damage free cable installation.

PART 2 - PRODUCTS

2.1 GENERAL

A. Each reel shall have a weather-resistant manufacturer’s identification tag securely attached to the reel and shall contain the following information:
1. Manufacturer’s name and cable trade name.
2. Conductor size and voltage.
3. Identification of insulation and jacket.
4. Order number.
5. Manufacturer’s order number.
6. Footage.
7. UL label.

B. All cable furnished and installed shall be listed by UL for the specific type of installation (conduit, duct, cable tray, etc.) shown on the drawings.

C. All conductors shall be copper.

D. Conductors shall have standard stranding for sizes as follows: 7 strands up through No. 2; 19 strands from No. 1 AWG through No. 4/0; 37 strands from 250 MCM through 500 MCM; and 61 strands from 600 MCM through 1,000 MCM, unless otherwise noted on the drawings.

E. Single-conductor insulation shall be black unless otherwise specified on the drawings. Multiple-conductor cables must contain phase identification by means of letters, numbers, or colored tapes over individual conductor insulations. The color of the individual conductor insulation may be all black or manufacturer's standard for the type cable specified.

F. Surface mark cables at regular intervals, not exceeding 24 in. in accordance with NEC Article 310-11.
1. Manufacturer’s name.
2. Conductor AWG or KCMIL.

3. Voltage Rating.
4. Direct burial/Sunlight resistant.
5. Identification of insulation.
6. For “CT USE”, sizes 1/0 AWG and larger.
7. Year of manufacturer.
8. UL Type MV-105.

2.2 CABLE, 5,000 VOLT, SINGLE CONDUCTOR, SHIELDED

A. The cables specified on the drawings as 1/C-5 kV shall be single-conductor, shielded, solid-dielectric type rated for 90°C operation. The cables shall be listed by UL as Type MV-90 and have a 5,000-V rating.

B. The conductor shall be stranded copper, sized in accordance with the drawings. The insulation level shall be 133% of rated voltage with a minimum thickness of 115 mils.

C. The cables shall conform to the following:
1. The cable shall have EPR insulation and be constructed in conformance with NEMA Standard WC 8 and AEIC Specification CS6.

2.3 CABLE, 15,000 VOLT, SINGLE CONDUCTOR, SHIELDED

A. The cables specified on drawings as 1/C-15 kV shall be single-conductor, shielded, solid-dielectric type rated for 150°C operation. The cables shall be listed by UL as Type MV-150 and have a 15,000-V rating. Sizes 1/0 and larger shall be listed “For CT Use” in accordance with the NEC. All cables shall be “sunlight resistant.”

B. The conductor shall be stranded copper, sized in accordance with the drawings. The insulation level shall be l33% of rated voltage with a minimum thickness of 220 mils per requirements of ICEA-S-68-516, UL-1072, and AEIC C56.

C. The cables shall conform to the following:
1. Cables shall be suitable for use in wet and dry locations, underground duct systems, and cable trays under approved installation practice as recommended by the cable manufacturer and the NEC.
2. All ethylene propylene insulated cable shall be rated for 105 degrees C for normal operation, 140 degrees C in emergency overload operation and 250 degrees C in short-circuit operation and shall comply with the following sections of the National Electrical Code NFPA 70-1999:
   a. Ampacities: Article 310 and 318-13
   b. Wiring Methods: Article 300 and 710
   c. Cable Trays: Article 310
   d. Bending Radius: Article 326
3. Conductors shall be Class B Compact Copper per ICEA S-68-516 Part 2 and UL 1072.
4. Each conductor shall be covered with an extruded semi-conducting polymeric material applied over he surface of the conductor that is compatible with the insulation.
5. The insulation applied over the extruded strand screen shall be high-quality ethylene propylene blended and compounded within the cable manufacturer’s facilities under optimum conditions of cleanliness.
6. The type of insulation shielding shall be one of the following designs:
   a. Copper Tape Shielding: The insulation of each conductor shall be covered with an extruded semi-conducting insulation screen meeting the requirements of ICEA S-68-516, UL 1072 and AEIC Cs6-87. Each conductor shall have a bare 5-mil minimum thick copper shielding tape helically applied over the insulation shield with a minimum 25% overlap of the tape width.

b. Combination Metallic Insulation Shield and Jacket: The cable shield shall consist of six corrugated copper drain wires laid parallel to the center axis of the conductor and embedded in a flame-resistant semi-conducting Chlorinated Polyethylene (CPE) jacket which meets or exceeds the requirements of ICEA S-68-516, Part 4.1.1.1.

7. The manufacturer shall utilize a true triple-extrusion single-pass manufacturing process when applying the strand shield, insulation and insulation shield concurrently to assure that the cable core is virtually corona free.
8. The cable jacket shall be either a flame-resistant CPE or flame-resistant PVC with a minimum average thickness of 80 mils.
9. Cable shall be equal to BICC Cables Specification # Unishield-P0001 or BICC Cables Specification # Uniblend/PVC P-0001.

2.4 CABLE, 5,000 VOLT, THREE CONDUCTOR, SHIELDED

A. The cables specified on drawings as 3/C-5-kV shall be three-conductor, individually shielded, solid-dielectric type. The cable assembly shall contain one stranded copper ground wire and shall be rated for 90^{o}C operation. The cable shall be listed by UL as Type MV-90 and have a 5,000-V rating.

B. The conductors shall be stranded copper, sized in accordance with the drawings. The insulation level shall be 133% of rated voltage with a minimum thickness of 115 mils on individual conductors. The insulation shielding shall be uncoated copper tape.

C. The cables shall conform to the following:
1. The cable shall have EPR-insulated conductors and an overall PVC jacket and be constructed and tested in conformance with NEMA Standard WC 8 and AEIC Specification CS6.

2.5 CABLE, 15,000 VOLT, THREE CONDUCTOR, SHIELDED AND ARMORED

A. The cables specified on drawings as 3/C-15-kV armored shall be three-conductor, individually shielded, solid-dielectric type with an overall interlocked armor. The cable assembly shall contain one or more stranded copper ground wires and shall be rated for 150^{o}C operation. The cable shall be listed by UL as Type MV-150 and have a 15,000-V rating. Sizes I/0 and larger shall be listed “For CT Use” in accordance with NEC. All cables shall be “sunlight resistant”.

B. The conductors shall be stranded copper, sized in accordance with the drawings. The insulation level shall be 133% of rated voltage with a minimum thickness of 220 mils on individual conductors per requirements of ICEA S-68-516, UL-1072, and AEIC CS6. The insulation shielding shall be uncoated copper tape, and the interlocked armor shall be galvanized steel with an overall PVC jacket.

C. The cables shall conform to the following:
1. Cables shall be suitable for use in wet and dry locations, underground duct systems, and cable trays under approved installation practice as recommended by the cable manufacturer and the NEC.
2. All ethylene propylene insulated cable shall be rated for 105 degrees C for normal operation, 140 degrees C in emergency overload operation and 250 degrees C in short-circuit operation and shall comply with the following sections of the National Electrical Code NFPA 70-1999:
a. Ampacities: Article 310 and 318-13
b. Wiring Methods: Article 300 and 710
c. Cable Trays: Article 310

d. Bending Radius: Article 326

3. Conductors shall be Class B Compact Copper per ICEA S-68-516 Part 2 and UL 1072.
4. Each conductor shall be covered with an extruded semi-conducting polymeric material applied over he surface of the conductor that is compatible with the insulation.
5. The insulation applied over the extruded strand screen shall be high-quality ethylene propylene blended and compounded within the cable manufacturer's facilities under optimum conditions of cleanliness.
6. The type of insulation shielding shall be one of the following designs:
   a. Copper Tape Shielding: The insulation of each conductor shall be covered with an extruded semi-conducting insulation screen meeting the requirements of ICEA S-68-516, UL 1072 and AEIC Cs6-87. Each conductor shall have a bare 5-mil minimum thick copper shielding tape helically applied over the insulation shield with a minimum 25% overlap of the tape width.
   b. Combination Metallic Insulation Shield and Jacket: The cable shield shall consist of six corrugated copper drain wires laid parallel to the center axis of the conductor and embedded in a flame-resistant semi-conducting Chlorinated Polyethylene (CPE) jacket which meets or exceeds the requirements of ICEA S-68-516, Part 4.1.1.1.
7. The manufacturer shall utilize a true triple-extrusion single-pass manufacturing process when applying the strand shield, insulation and insulation shield concurrently to assure that the cable core is virtually corona free.
8. The cable jacket shall be either a flame-resistant CPE or flame-resistant PVC with a minimum average thickness of 80 mils.
9. Cable shall be equal to BICC Cables Specification #Unishield-P0001 or BICC Cables Specification #Uniblend/PVC P-0001.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that manholes, conduit, and trench are ready to receive work.

B. Verify field measurements are as shown on drawings.

C. Beginning of installation means installer accepts existing conditions.

3.2 PREPARATION

A. Thoroughly swab conduits to remove foreign material before pulling cables.

3.3 INSTALLATION

A. Install cable and terminations in accordance with manufacturer's instructions and to ANSI/IEEE C2-97.

B. Ground cable shield at each termination and splice at equipment or manhole.

C. No not pull any cable until the conduit system is complete from pull point to pull point.

D. Exercise care while installing cable in conduits so as not to damage the conductor insulation. Ideal Industries' "Yellow-77" or "Wire Lube" or American Polywater Corporation's "Polywater J or J-WG" compound may be used in pulling nonarmored conductors and shall be used if cable is pulled by mechanical means.

E. The bending radius of any cable shall not be less than the minimum recommended by the manufacturer. Maximum pulling tension and sidewall pressure of any wire or cable shall not exceed the manufacturer's recommended values.

F. Install cable in manholes along those walls providing the longest route and most spare cable lengths. Arrange cable to avoid interferences with duct entrances into manhole.

G. Fireproof cables in manholes, pullboxes, and vaults and exposed high-voltage cable terminations at transformers, potheads, etc. The fireproofing material shall be 3M Company "Irvington" No. 7700 ARC and fireproofing tape or an approved equal. Application of the tape, securing of tape to the cable, and other installation details shall be in accordance with manufacturer's recommendations.

3.4 FIELD QUALITY CONTROL

A. General:
1. Check exposed cable sections for physical damage. Verify that cable is connected according to drawings and that shield grounding, cable support, and terminations are properly installed.
2. In setting up the test set, take special safety precautions regarding grounding of the test equipment. Ground the test set, its sphere gap (if used), its voltmeter, and the cable sheath to the same ground.
3. Attend exposed cable connections throughout the duration of the test. The machine operator shall coordinate the overall safety effort although each organization is individually responsible for the safety of its personnel.
4. Insulating gloves shall be worn by test personnel making connections during all tests.
5. Assure test values applied do not exceed the maximum permissible field test value of any component part included in the test.
6. Minimum acceptable resistance readings for 15kV cables shall be 5000 megohms for cable lengths of 1000 ft or less. On installations exceeding 1000 ft and where readings fall below this minimum, acceptance shall be at the discretion of the CM.

B. Test No. 1 - Shield Continuity:
1. Make a continuity test of metallic shields with an ohmmeter.

C. Test No. 2 - Insulation Resistance No. 1:
1. Give the insulation an "Insulation Resistance Test" using a 2500-V insulation tester (Simpson Model 405 or approved equal). Make this test before the "DC High-Potential Test" (Test No. 3).
2. Test all 1/C insulated cables between conductor and ground with the cable shield grounded.
3. Test all multiconductor insulated cables between one of the conductors and ground with the other two conductors and cable sheath (if shielded) grounded to the same ground. Successfully test each conductor in the same manner.
4. Apply the voltage for a long enough duration to fully charge the cable. Take resistance readings every 15 s during the first 3 min and at 1-min intervals thereafter. Continue the test until three equal readings, 1 min apart, are obtained. The cable then may be considered to be fully charged.
5. Minimum acceptable resistance readings for 5-kV cables shall be 2,000 megohms for cable lengths of 1,000 ft or less. On installations exceeding 1,000 ft and where readings fall below this minimum, acceptance shall be at the discretion of the CM.
6. Minimum acceptable resistance readings for 15-kV cables shall be 5000 megohms for cable lengths of 1000 ft. or less. On installations exceeding 1000 ft. and where readings fall below this minimum, acceptance shall be at the discretion of the CM.

D. Test No. 3 - High Potential:
   1. Make a "DC High-Potential Test" after all splices, potheads, and stress cones are made. This test shall be in accordance with IEEE Standard 400.
   2. Make the "DC High-Potential Test" only after the CM has approved an initial "Insulation Resistance Test" and before terminal equipment, such as condensers, transformers, etc., have been connected.
   3. Test all 1/C insulated cables between conductor and ground with the cable shield grounded.
   4. Test all multiconductor insulated cables between one of the conductors and ground with the other two conductors and cable sheath grounded to the same ground. Successfully test each conductor in the same manner.
   5. The preferred method of conducting the "DC High-Potential Test" is with the negative lead of the high-potential machine connected to the cable under test and the positive lead connected to ground. If a positive-ground machine is unavailable, make the test with the polarity opposite that indicated. In either case, state in the test report which kind of machine was used.
   6. The "DC High-Potential Test" voltages shall be 25 kV for 5-kV rated cables and 55 kV for 15 kV rated cables.
   7. For 5 kV cables, apply test voltage slowly, from an initial value not to exceed 5 kV, in increments of equal value (4 kV max, 2 kV min) to the maximum specified level. Allow sufficient time (1 min suggested) at each step for the leakage current to stabilize or to show unreadably low values. Record leakage current at the end of each step duration.
   8. For 15 kV cables, apply test voltage slowly, from an initial value not to exceed 25 kV, in increments of equal value (6 kV max, 2 kV min.) to the maximum specified level. Allow sufficient time (1 min suggested) at each step for the leakage current to stabilize or to show unreadably low values. Record leakage current at the end of each step duration.
   9. Maintain the maximum test voltage (25 kV for k kV cables and 55 kV for 15 kV cables) for 5 consecutive minutes. Record the leakage current values at 1-min intervals.
   10. Should the leakage current values significantly increase during the soak period, abort the test. Proceed with retest only after approval from the CM.
   11. After successful completion of the test duration or a failure is experienced, remove the test potential at approximately the same rate as used during its application. Allow the residual voltage on the circuit to decay to at least 20% (5 kV) of the test voltage before applying manual grounds. Do not start a retest or reconnection of circuit components until the cable has been solidly grounded for a period at least four times (20 min) the test duration.
      a. Caution: It should be recognized that direct-current charges can build up potentially dangerous levels if grounds are removed before absorption energy is dissipated.
   12. For the cable to be acceptable, the steady-state leakage current values at maximum test voltage must be approximately equal and, in general, less than 25 microamperes.
   13. Do not subject cables to more than one "DC High-Potential Test" without the approval of the CM. The maximum test voltage for a second test, should it be necessary, shall be as specified by the CM.

E. Test No. 4 - Insulation Resistance No. 2:
   1. Give the cable a second "Insulation Resistance Test" using a 2500-V insulation tester (Simpson Model 405 or approved equal) after completion of Test No. 3.
   2. For the cable to be acceptable, the resistance readings must be reasonably parallel to Test No. 2 "Megger" readings.

3.5 CLEANING

A. Clean all construction debris from all underground structures to a broom clean appearance.

B. Clean all construction debris from all equipment enclosures to a vacuumed appearance.

END OF SECTION 16121